Nitrogen, Water and Global Change – an Integrated Modeling Perspective

Carolien Kroeze[1*], Maryna Strokal[1], Xuanjing Chen[1,3], Annette B.G. Janssen[1], Ang Li, Lin Ma[2], Mengru Wang[1], Dianneke van Wijk[1], Chen Xi[1], Jing Yang[2]

[1] Water Systems and Global Change Group, Wageningen University & Research, Droevendaalsesteeg 3, 6708 PB Wageningen, The Netherlands
[2] Key Laboratory of Agricultural Water Resources, Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences, 286 Huaizhong Road, Shijiazhuang 050021, China
[3] College of Resources and Environment, Southwest University, Chongqing, China

*Email: carolien.kroeze@wur.nl

Abstract

Nitrogen pollution is an important issue in many in aquatic systems. This paper discusses approaches to model nitrogen and water under global change. Emphasis will be paid to integrated model systems that cover causes, effects and solutions of nitrogen pollution in different aquatic systems: rivers, lakes, groundwater and coastal seas. Attention will be paid to impacts of global change on future water quality and water quantity, and the availability of clean water for nature and society. Examples will be given of global and regional modelling studies on the causes of the problem and on possible future solutions.

Keywords: nitrogen, water, model, global change, water stress

1. Introduction

Nitrogen pollution is an important issue in many in aquatic systems worldwide. There are many causes of this pollution, ranging from food production to industries and urban waste water. The negative impacts therof pose a threat to ecosystems and society. Eutrophication is an issue in fresh and marine waters. In addition, nitrate in groundwater can be a problem for drinking water. The variety of causes and effects complicates the search for effective solutions. In the future, this may even be more difficult as a result of population growth, economic development, an the associated increased demand for food and energy. Moreover, climate change may affect water quality, and the effectiveness of pollution management.

This paper discusses approaches to model nitrogen and water under global change. Emphasis will be paid to integrated model systems that cover causes, effects and solutions of nitrogen pollution in different aquatic systems: rivers, lakes, groundwater and coastal seas. Attention will be paid to impacts of global change on future water quality and water quantity, and the availability of clean water for nature and society.

2. Modeling Nitrogen in Water Systems – Some Illustrative Examples

Figure 1 gives a schematic overview of integrated water modeling of nitrogen water under global change. Many examples of modeling studies exist (van Vliet et al., 2019). In this paper, we give some illustrative examples of global and regional modelling studies on the causes of the problem and on possible future solutions. Our examples are models for lakes (Yang et al., 2019, Wang et al., 2019, Li et al., 2019, Janssen et al., 2019), rivers (Chen et al., 2019b, Chen et al., 2019a, Beusen et al., 2015) and coastal waters (Strokal et al., 2016). These selected examples focus on the causes of nitrogen pollution, as well as future solutions.

3. Lessons

Based on the abovementioned examples, we wlll draw lessons for future modeling studies. We will argue that there is a need for integrated modeling studies. There is a need for models that can translate global challenges into local solutions. This requires an intregration of water, nutrient and crop models, while accounting for socio-economic drivers, the effectiveness of solutions as well as the impacts of global and climate change. Such model systems can help to assess the availability of clean water for nature and society in the future.
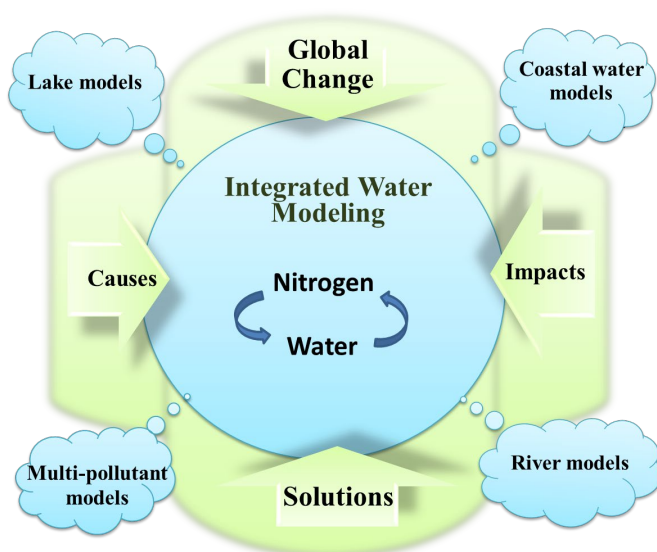

Fig. 1: Schematic overview of integrated water modeling of nitrogen water under global change. Water systems include lakes, rivers and coastal waters. Integrated modeling refers to modeling causes, effects and solutions.

References

BEUSEN, A. H. W., VAN BEEK, L. P. H., BOUWMAN, A. F., MOGOLLÓN, J. M. & MIDDELBURG, J. J. 2015. Coupling global models for hydrology and nutrient loading to simulate nitrogen and phosphorus retention in surface water – description of IMAGE–GNM and analysis of performance. *Geosci. Model Dev.,* 8**,** 4045-4067.

CHEN, X., STROKAL, M., KROEZE, C., MA, L., SHEN, Z., WU, J., CHEN, X. & SHI, X. 2019a. Seasonality in river export of nitrogen: A modelling approach for the Yangtze River. *Science of The Total Environment,* 671**,** 1282-1292.

CHEN, X., STROKAL, M., VAN VLIET, M. T. H., STUIVER, J., WANG, M., BAI, Z., MA, L. & KROEZE, C. 2019b. Multi-scale Modeling of Nutrient Pollution in the Rivers of China. *Environmental Science & Technology,* 53**,** 9614-9625.

JANSSEN, A. B. G., JANSE, J. H., BEUSEN, A. H. W., CHANG, M., HARRISON, J. A., HUTTUNEN, I., KONG, X., ROST, J., TEURLINCX, S., TROOST, T. A., VAN WIJK, D. & MOOIJ, W. M. 2019. How to model algal blooms in any lake on earth. *Current Opinion in Environmental Sustainability,* 36**,** 1-10.

LI, X., JANSSEN, A. B. G., DE KLEIN, J. J. M., KROEZE, C., STROKAL, M., MA, L. & ZHENG, Y. 2019. Modeling nutrients in Lake Dianchi (China) and its watershed. *Agricultural Water Management,* 212**,** 48-59.

STROKAL, M., KROEZE, C., WANG, M., BAI, Z. & MA, L. 2016. The MARINA model (Model to Assess River Inputs of Nutrients to seAs): Model description and results for China. *Science of The Total Environment,* 562**,** 869-888.

VAN VLIET, M. T. H., FLÖRKE, M., HARRISON, J. A., HOFSTRA, N., KELLER, V., LUDWIG, F., SPANIER, J. E., STROKAL, M., WADA, Y., WEN, Y. & WILLIAMS, R. J. 2019. Model inter-comparison design for large-scale water quality models. *Current Opinion in Environmental Sustainability,* 36**,** 59-67.

WANG, M., STROKAL, M., BUREK, P., KROEZE, C., MA, L. & JANSSEN, A. B. G. 2019. Excess nutrient loads to Lake Taihu: Opportunities for nutrient reduction. *Science of The Total Environment,* 664**,** 865-873.

YANG, J., STROKAL, M., KROEZE, C., WANG, M., WANG, J., WU, Y., BAI, Z. & MA, L. 2019. Nutrient losses to surface waters in Hai He basin: A case study of Guanting reservoir and Baiyangdian lake. *Agricultural Water Management,* 213**,** 62-75.